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(54) **Movement of Electroerosion Electrode**

(57) Drilling small holes, in superalloys in particular, by using conventional cutting drills, results in drill breakage and burr generation. Electro erosion eliminates those problems but numbers of holes have to be drilled simultaneously to make the process economical. The invention provides a head (10) which holds a number of radially aligned and radially movable electrodes 14 and a workpiece 22 at its centre. A sleeve 26 surrounds the outer ends of the electrode (14) and has an inner, frusto conical surface (28) which engages them. Vertical reciprocation of the sleeve (26) pushes the electrodes inwards and allows them to be urged outwards by springs (16) to enable the appropriate relative motion between electrodes (14) and workpiece (22). Alternatively a row of electrodes is engaged by a plane surface, formed on a vertically reciprocable member which is inclined to the direction of movement of the electrodes.

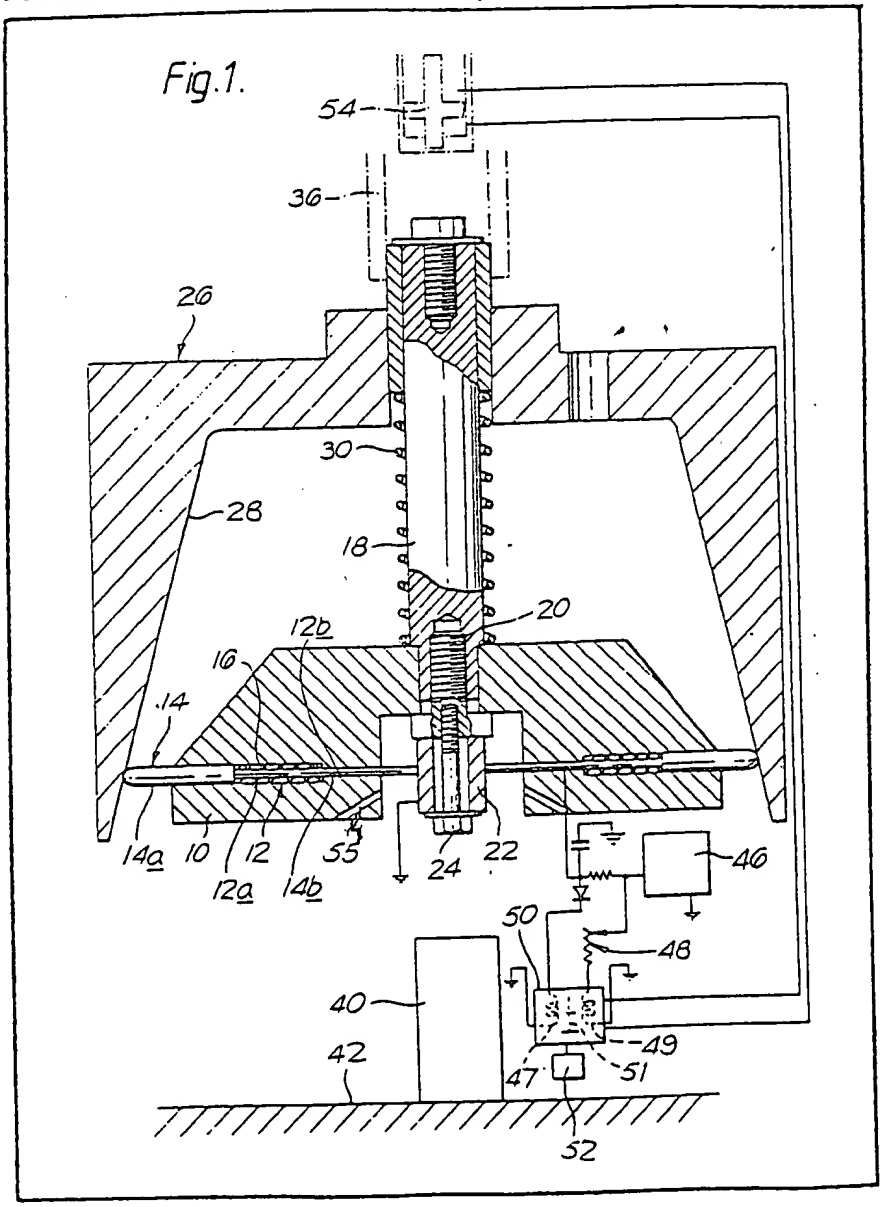

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Fig.1.

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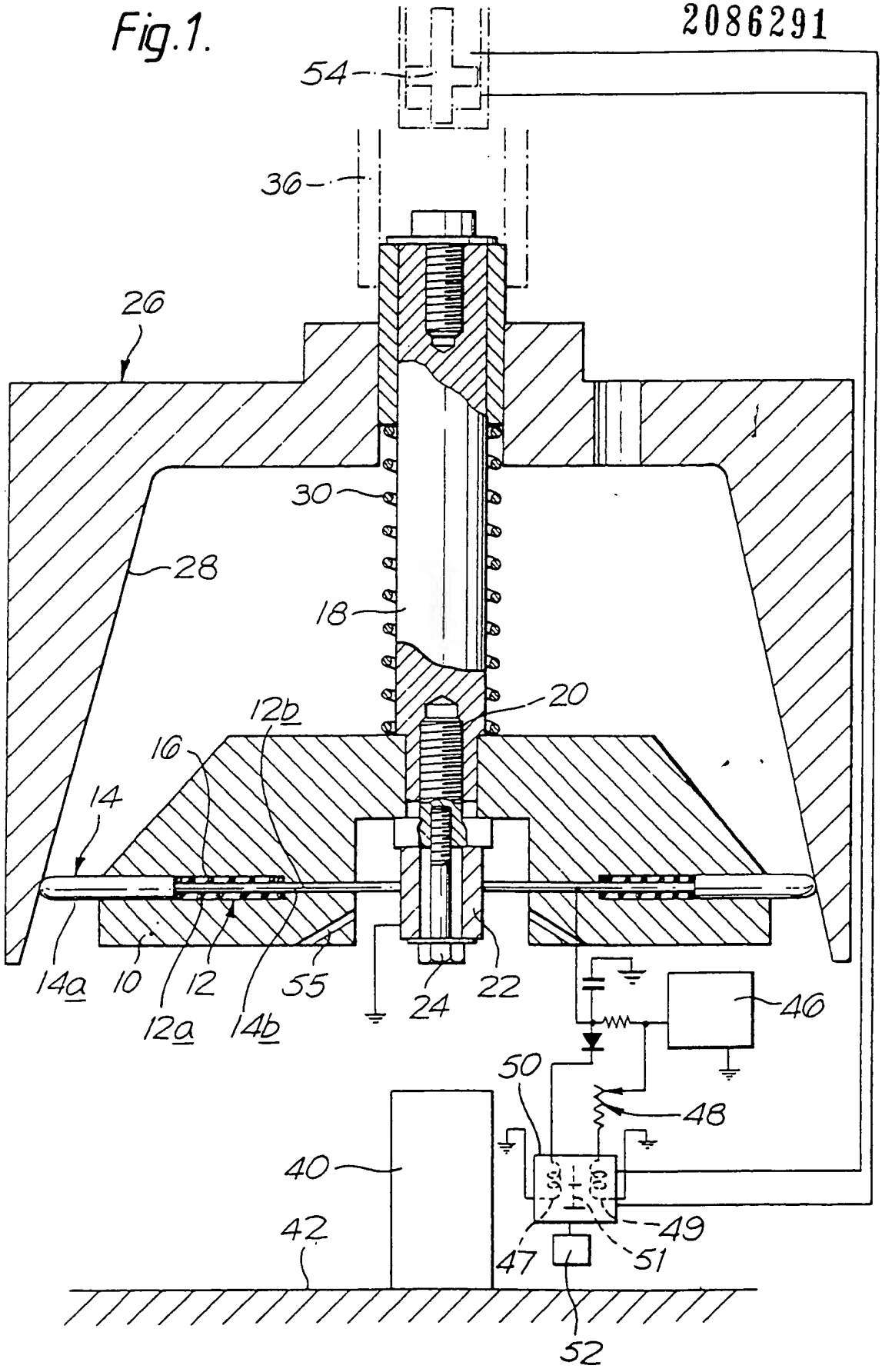

SPECIFICATION
Machine Tool

This invention is concerned with a machine tool.

More particularly the invention relates to a machine tool of the kind which removes metal by the electro discharge technique. However, the invention is equally applicable to machine tools of the kind which remove metal electro-chemically or electrolytically.

The machining of small holes e.g. in the range 0.25 mm (.010") to 2.5 mm (0.100") diameter by conventional cutting tools, presents problems in that sometimes the drill "wanders" and produces a hole which is not in its required position. Further, the drill being small, it is difficult to flush swarf from the hole as it deepens and, with the result that the drill breaks further stil, machining by cutting invariably forms burns at start and/or finish of the operation which sometimes necessitates further deburring operations.

The use of supperalloys for the manufacture of artefacts has aggravated the problems mentioned hereinbefore and so, new methods of machining have been developed, namely electro-chemical, electrolytic and electro-discharge machining, none of which use cutting tools and, all of which are now *per se*, part of the state of art.

In the substitution of the new, none cutting techniques, it has been realised that they are unable to remove metal as fast as cutting tools. The invention therefore seeks to provide an improved machine tool of the kind which utilises an electrode and a flow of fluid having given electrical characteristics for the removal of metal from a workpiece.

According to the present invention there is provided a machine tool comprising a head which is adapted for the support of a plurality of spaced electrodes such that during operation of the machine tool said electrodes may be moved across the head towards a work-piece position, a plurality of electrodes and, a member arranged for reciprocatory movement relative to said head and having a surface inclined to the direction of movement of said electrodes and engaging with the said electrodes at positions which are remote from the work-piece position, so that on said reciprocation occurring, said electrodes are urged towards the workpiece position by one half reciprocation of the member and, away from the workpiece position by resilient means during the return half reciprocation of the member.

The head may include workpiece support means.

The head may include passages within each of which an electrode is supported for relative reciprocatory sliding movement.

Preferably each passage and each electrode have complementary steps between which a spring is trapped so as to urge the respective electrode away from a workpiece position.

The inclined surface of the member may be a plane surface.

Alternatively, the inclined surface may be a frusto conical surface.

The frusto conical surface may be female.

Alternatively the frusto conical surface may be male.

Preferably the member is resiliently supported from the head.

The relative reciprocatory movement of the member may be brought about by a servo mechanism which in operation is controlled by said voltage variations across the or each electrode and a workpiece.

The invention will now be described, by way of example and with reference to the accompanying drawings in which:

Figure 1 is a cross-sectional view through a machine tool head in accordance with a first embodiment of the invention,

Figure 2 is a cross-sectional view through a machine tool head in accordance with a further embodiment of the invention,

Figure 3 is a part cross-sectional view through a machine tool head in accordance with a still further embodiment of the inventions and

Figure 4 is a part view of a machine tool head in accordance with a further embodiment of the invention,

Figure 5 is a part cross-sectional view of a further embodiment of the invention and,

Figure 6 is a view on line 6—6 of Figure 5.

In Figure 1 a machine tool head 10 comprises a disc in which are formed a number of passages 12. Each passage 12 has a passage portion 12*a* and a passage portion 12*b* which is of smaller diameter than passage portion 12*a*.

An electrode 14 is slidably mounted in each passage 12 and has differing diameters 14*a*, 14*b*. The shoulders formed by the differing diameters of each passage 12 and electrode therebetween. Should the electrodes be pushed inwards towards the axis of the head 10, springs 16 will be compressed and on removal of the force, springs 16 will urge the electrodes 12 outwards again.

Head 10 is tried to shafts 18 by a screw 20. Screw 20 supports a workpiece 22, in the present example a brush, by means of a further screw 24 which traps bush 22 against the head of screws 20.

An annular member 26 surrounds head 10 and is arranged to slide on shaft 18 in a reciprocatory manner, relative to head 10.

The inner surface 28 of the member 26 is in the form of a frusto cone and member 26 is positioned so that surface 28 engages the outer end of each electrode 14.

A coil spring 30 maintains member 26 in a nominal position relative to head 10.

The upper end of shaft 18 is attached to a machine frame (not shown) *via* e.g. a collet 36, shown diagrammatically.

The portion of the machine frame (not shown) to which the assembly is attached is e.g. a saddle which can be moved in a reciprocatable manner.

In operation the saddle (not shown) which carries head 10 and member 26 is lowered until

the head of screw 24 contacts a stop 40 which is fixed to machine table 42.

Machining electrical power is switched on at a supply point 46 and an electrical potential is set up, across each electrode 14 and workpiece 22. A reference voltage 48 is initiated at the same time.

Initially the electrical potential across electrodes 14 and workpiece 22 will be high, by virtue of the gap between them. The high potential is used *via* a winding 47 to effect movement of a spool valve 51 in box 50. The movement is effected against opposition from a further winding 49 in box 50 which receives its motivating signal from reference voltage 48.

Movement of the spool valve 51 enables pressurised hydraulic fluid to be passed from a supply source 52, to the upperside of a piston 54, which is attached by any convenient means, to the saddle (not shown). The saddle (not shown) is thus moved downwards and *via* collet 36, moves member 26 with it member 26 moves against spring 30 and relative to head 10. It therefore acts *via* frusto conical surface 28, on the ends of electrode 14, pushing them towards workpiece 22.

During this time, a pressurised flow of dielectric fluid is directed *via* nozzles 54, at a place on the workpiece with which each electrode is aligned. The dielectric fluid helps to prevent breakdown of the resistance across the gap until electrical conditions are as desired and, to wash away dislodged particles of workpiece material.

When member 26 has moved electrodes 14 sufficiently near workpiece 22 for resistance to breakdown, current passes to workpiece 22 with sufficient energy to remove a particle of material. There is of course a simultaneous drop in voltage which is sensed by winding 49 with the result that reference voltage 48 becomes dominant and operates its winding and moves the spool valve 51 in box 50, so as to cause hydraulic fluid to pass to the lower side of piston 54. There results a lifting of member 26 which allows springs 16 to urge electrodes 14 away from workpiece 22, thus increasing the electrical potential across them. The machining action is self perpetuating and any suitable means may be provided, to cut off machining electrical power, when a desired hole depth is attained.

Electrolytic machining would also require member 26 to reciprocate, but electro chemical machining would require member 26 to retract only if any or all of electrodes 14 touched the workpiece 22 which would result in a voltage drop there across.

In Figure 2 an arrangement is shown, which includes a ring 60 which supports a number of electrodes 14 in a manner similar to that of disc 10 of Figure 1.

Electrodes 14 are ringed by springs 16 towards the axis of ring 60 and against the frusto conical surface 62 on the end of a rod 64. Movement of rod 64 vertically upwards pushes electrodes 14 towards a workpiece 66. Downward movement of rod 64 allows springs 16 to urge electrodes away from workpiece 66. The taper of the frusto cone may be reversed as depicted by chain dotted lines 67.

A servo system similar to that described in connection with Figure 1 may be utilised for the arrangement of Figure 2.

Figure 3 shows a further arrangement in that the electrodes 14 engage a plane surface 70 which is at an angle of less than 98 with respect to the longitudinal axis of each electrode 14.

Plane surface 70 is formed in a member 72 which is caused to reciprocate vertically, as described hereinbefore.

In Figure 4 a member 76 has a varying profile 78 which enables some electrodes 14 to move a greater distance than the remainder, for a given vertical movement of member 76.

The operative ends of the electrodes 14 may have shapes other than being merely flat e.g. they may be arcuate or semi spherical.

Referring now to Figure 5 which depicts a further embodiment of the invention. The machine tool head comprises a double flanged boss 80. The flanges 82, 84 thereof have opposed, radially extending portions 86, 88 each of which is provided with slots 90, 92 (Figure 6) respectively.

Disc shaped electrodes 94, 96 lie between respective extending portions 86, 88 only one of the electrodes 96 being shown in Figure 5. Electrodes 94, 96 are rotatably mounted on axles 98, 100, which lie between respective slots 90, 92.

Each electrode engages the sloping inner surface of member 102 which not only reciprocates vertically in the manner described in connection with Figures 1 to 4, but also during operation, continually rotates about the axis of shaft 104. A bearing 106 reduces friction therebetween.

The electrodes 94, 96 protrude into a space 108 defined by boss 80 and wherein a workpiece 110 is positioned so as to have arcuate slots machined in it by the electrodes 94, 96.

Referring to Figure 6, leaf springs 112, 114 are fixed in pegs 116 on the upper and lower surfaces and have free ends which cross each other to provide locations for axles 98, 100.

In operation, movement of member 102 downwards, pushes electrodes 94, 96 inwards towards workpiece 110, against the resistance offered by leaf springs 112, 114. The simultaneous rotation of member 102 also rotates electrodes 94, 96 which ensures that different positions on the electrodes peripheries are presented to the workpiece on each downward movement of member 102.

Upward movement of member 102 permits leaf springs 112, 114 to push electrodes 94, 96 outwards again. The necessary reciprocating action of the electrodes, to achieve pulsed machining, is thus provided.

Claims

1. A machine tool comprising a head which is

adapted for the support of a plurality of spaced electrodes such that during operation of the machine tool said electrodes may be moved across the head towards a workpiece position, a plurality of electrodes and, a member arranged for reciprocatory movement relative to said head and having a surface inclined to the direction of movement of said electrodes and engaging with the said electrodes at positions which are remote from the workpiece position, so that on said reciprocation occurring, said electrodes are urged towards the workpiece position by one half reciprocation of the member and, away from the workpiece position by resilient means during the return half reciprocation of the member.

2. A machine tool as claimed in claim 1 wherein the head includes a plurality of passages within each of which an elongate electrode is supported for relative reciprocatory sliding movement.

3. A machine tool as claimed in claim 2 wherein each passage and electrode have complementary shoulders, between which a spring is trapped so as to urge the respective electrode away from said workpiece position.

4. A machine tool as claimed in any previous claim wherein the inclined face of the member is a plane surface.

5. A machine tool as claimed in any of claims 1 to 3 wherein the inclined surface of the member is a frusto cone.

6. A machine tool as claimed in claim 5 wherein the frusto cone is female.

7. A machine tool as claimed in claim 5 wherein the frusto cone is male.

8. A machine tool as claimed in any previous claim wherein the head includes workpiece support means.

9. A machine tool as claimed in any previous claim wherein the member is maintained in a nominal position with respect to the head, by resilient means.

10. A machine tool comprising a head substantially as described in this specification with reference to Figure 1 of the drawings.

11. A machine tool comprising a head substantially as described in this specification with reference to Figure 2 of the drawings.

12. A machine tool comprising a head substantially as described in this specification with reference to Figure 3 of the drawings.

13. A machine tool comprising a head substantially as described in this specification with reference to Figure 4 of the drawings.

14. A machine tool comprising a head as claimed in claim 1 wherein said electrodes have at least an accurately profiled portion.

15. A machine tool as claimed in claim 14 wherein said electrodes are fully circular and are supported by and in said head for rotation about an axis which is normal to the plane in which movement towards a workpiece position occurs.

16. A machine tool as claimed in claim 15 wherein said member rotates simultaneously with said reciprocation and an engagement with said electrodes, rotates them as well as moving them towards the workpiece position.

17. A machine tool comprising a head substantially as described in the specification with reference to Figure 5 and 6.

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Fig.2.

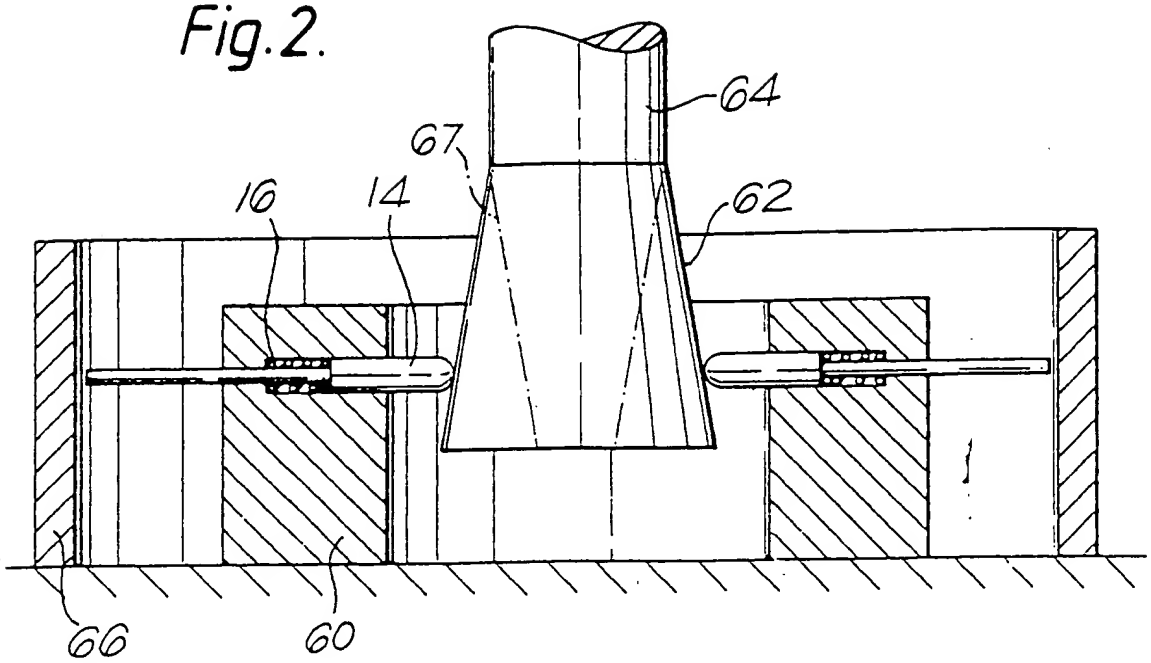

Fig.3.

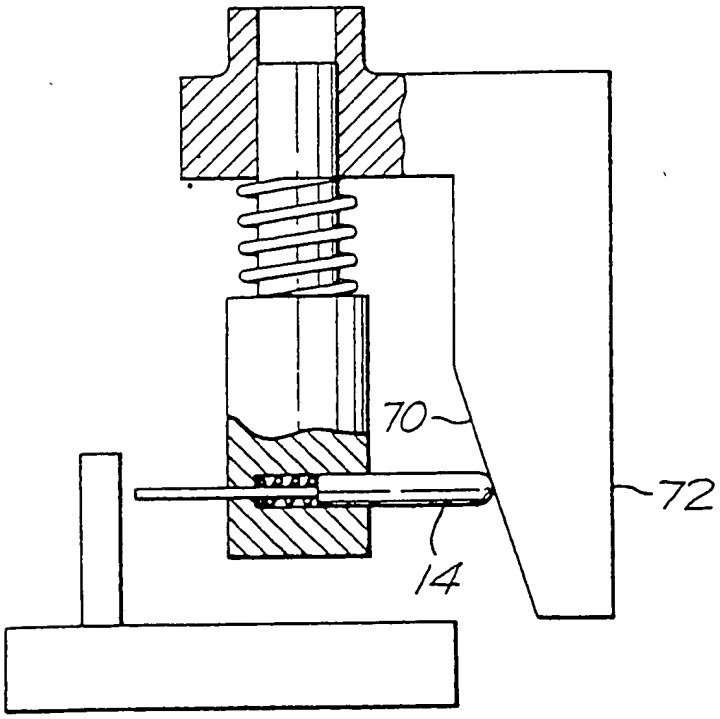

Fig.4.

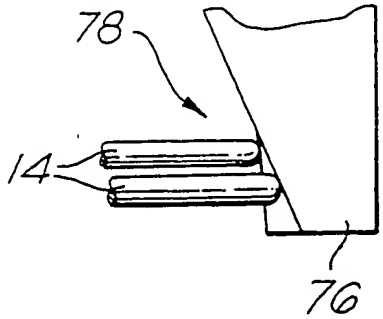

Fig.5.

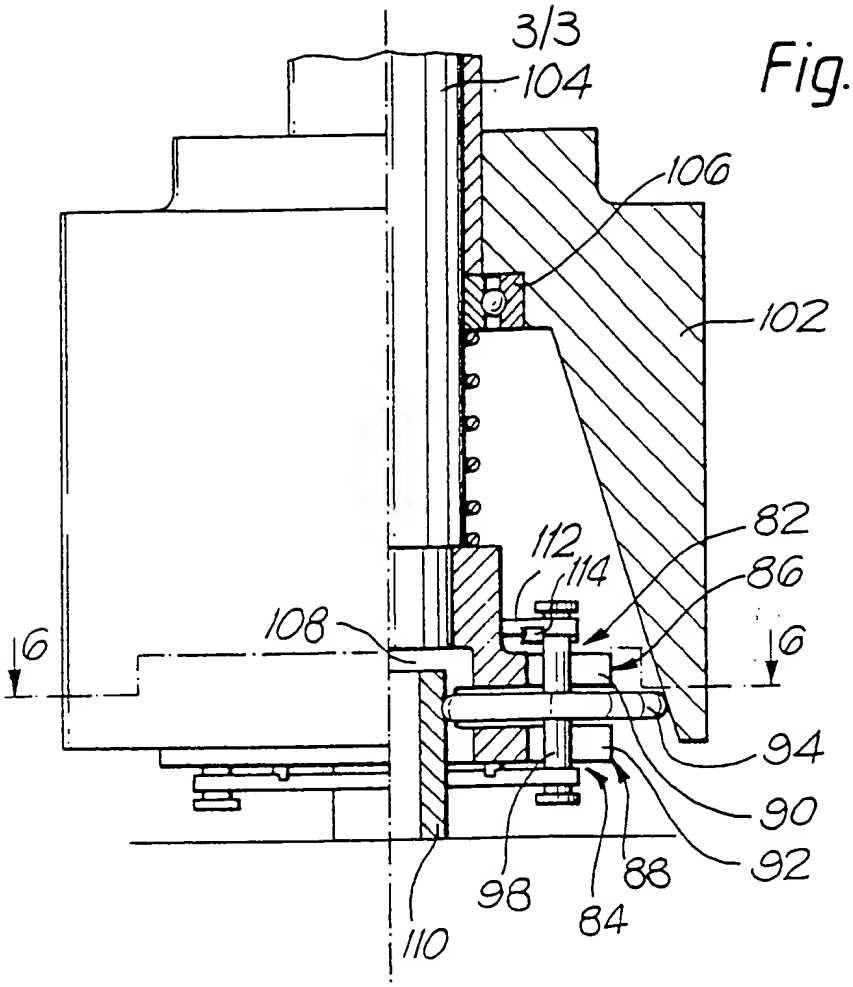
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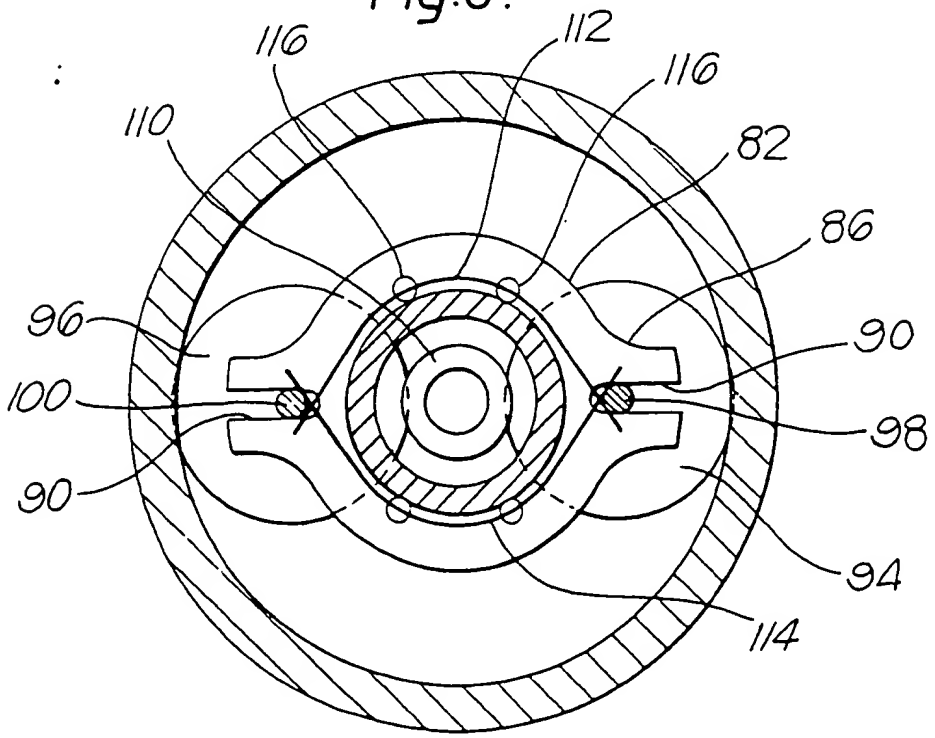
Fig.6.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